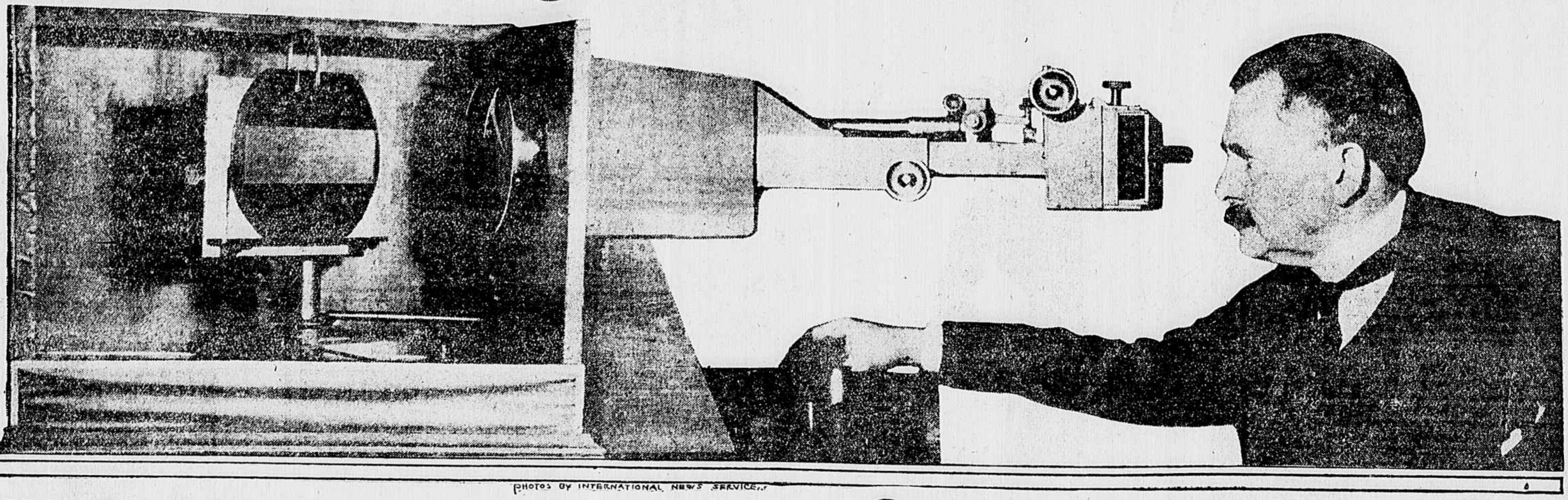
Reading Messages from the Sun and the Distant Stars.



PHOTOS BY INTERNATIONAL NEWS SERVICE.

Professor Michelson Observing the Diffraction Grating Through the Spectroscope at the University of Chicago.

New Scientific Discoveries Made Possible by the Amazing Labor of Prof. A. A. Michelson in Drawing 120,000 Perfectly Parallel Lines on a Little Piece of Metal

PROFESSOR A. A. MICHELSON, of the University of Chicago, has ruled 120,000 perfectly straight and parallel lines on a piece of metal 6 inches by 3 inches in area.

This piece of metal is called a diffraction grating, and its purpose is to split a ray of sunlight into the greatest number of shades of color ever seen. It is the basic part of the largest and most perfect spectroscope ever constructed.

The spectroscope, as most of us know, is an instrument that enables one to see the different colors of which a ray of sunlight is composed. In the simplest form of spectroscope the ray is split up by passing through a glass prism. In Professor Michelson's instrument it is split up by the lines on the diffraction grating.

The colors composing a ray of white sunlight are commonly stated to range from red at one end through orange, yellow, green, blue and indigo to violet at the other end. Before the red end of the spectrum are the invisible infra-red rays, and beyond the violet end are the invisible ultra-violet rays. The visible spectrum is divided into an infinite number of shades of color, and the value of Professor Michelson's instrument is that it measures the largest number of these shades so far observed. The colors indicate the nature and proportions of the metals and incandescent materials of which the sun is composed, and reveal other facts about the condition of the luminary. The spectroscope is our principal means of studying the nature and composition of the sun, the source of all life and light. The new observations which Professor Michelson makes with his spectroscope are, therefore, in the truest sense, messages from the sun.

The work of ruling 120,000 lines on a plate 6 inches by 3 inches is probably the most laborious and delicate task ever carried out. These lines are exactly one eleven-thousandth equidistant from one another and they are perfectly parallel. So accurate is the paralleling of these lines that if any two of them were extended for a mile there would not be a millionth part of an inch variation from the parallel.

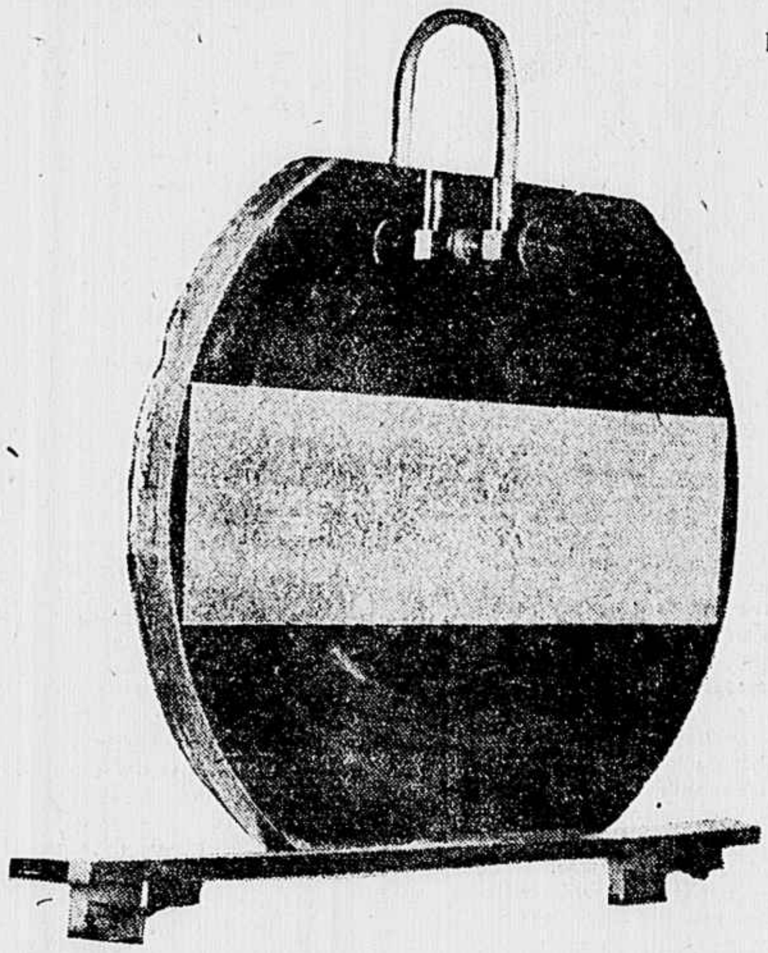
One of the remarkable uses of this spectroscope is that it will measure the difference between the wave lengths of various colored rays down to a millionth part of a centimetre, or one three-millionth of an inch, recording colors that no human eye ever saw. By means of photographic plates many facts will be learned from the spectroscope that the eye cannot detect.

The old original prismatic spectroscope separated a ray of light crudely into seven so-called primary colors—red, orange, yellow, green, indigo, blue and violet. The diffraction grating will split the ray into 120,000 different shades of color.

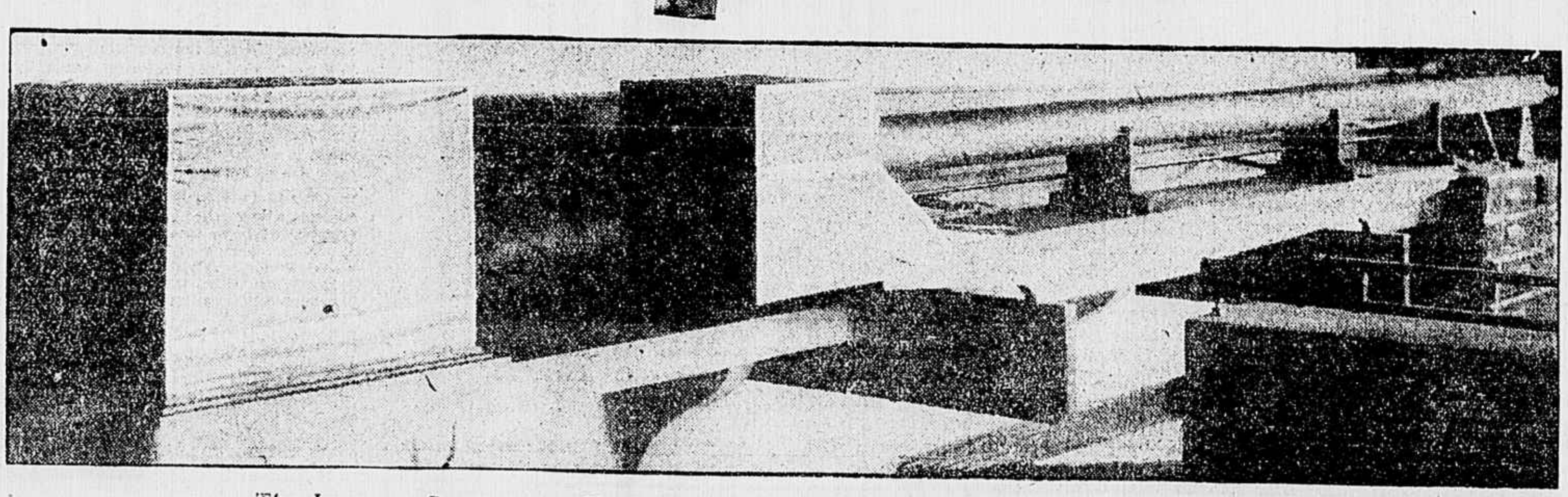
How to draw the lines on the grating was a great problem, apart from the tremendous labor involved. Several failures were made before a satisfactory method of doing the work was reached. The lines are drawn by a diamond point, and it had to be done so delicately that there was not the deviation of the breadth of a diamond point between any two of the 120,000 lines.

How to space them accurately was one of the greatest difficulties to be overcome. Professor Michelson tried to do this at first by placing his grating in a mercury bath. He would draw one line and then place the grating edgewise in the mercury bath. Then a measured drop of mercury was added, so as to raise the whole mercury surface a given excessively small degree. At the spot indicated by the mercury he would rule his next line. Then the plate was returned to the bath again and a new drop of mercury added. This process had to be repeated over and over again thousands of times.

But before he had gone very far the professor found that this method was not satisfactory. The reason was that it was impossible to measure the mercury drop with sufficient accuracy. Of course, he took the precaution to work always at the same temperature, so that there might be no variation in the size of the mercury drop, but it seems possible that some incalculable variation from this cause may have slipped in.



A Six-Inch by Three-Inch Piece of Metal, Containing 120,000 Lines, Held in Suspension Ready to Be Viewed Through the Spectroscope. The Lines on This Piece of Metal Are Known As "The Diffraction Grating."



The Immense Spectroscope Used by Prof. Michelson at the University of Chicago

After a great many trials and calculations he solved the problem of making perfectly parallel lines by a screw of exquisitely delicate thread. This was constructed so that by turning it the plate to be ruled was pushed forward one eleven-thousandth of an inch. There was still an infinitesimal error in the accuracy of the screw. When a screw, as near to perfect accuracy as possible had been constructed, then by careful experiment and mathematical calculation, the percentage of error of the screw was determined and the error corrected for each of the 120,000 lines that were drawn.

For a century men have tried and failed to cover as many inches with correctly drawn parallel lines as the American scientist has done. He himself worked on the problem for upwards of twelve years. Sometimes he would cover several inches with infinitesimal lines before he discovered the fatal error. Then he had to begin all over again.

It is stated that he hopes to construct an even more closely ruled diffraction grating in time.

The more highly this instrument is perfected the more we shall know of various conditions such as the weather that depend on changes in the sun.

"I am glad to say I have finished this grating," said Professor Michelson at his home in Chicago the other day. "It was very difficult—so many chances of error, you know, and error is fatal. Of course it has much higher resolving power than any of the smaller gratings that have been used in the past. I have been working twelve years to accomplish this. Many times I have made beginnings that were all right, but after ruling a hundred lines or so one would go wrong—and then there is nothing to do but start all over again. It tries one's patience."

Professor Michelson's work has been conducted at the Ryerson Laboratories at the University of Chicago. He has a specially constructed dark room in the basement of his building where much of the work has been done.

In order to have some slight conception of the importance of Professor Michelson's work it is necessary to understand the rudimentary principles of the science of the spectroscope and the spectrum. A ray of white sunlight is composed of an infinite series of rays of different wave-lengths. It is the wave-lengths that constitute the different colors. When all the colored rays are mixed together the result is a pure white ray, but when the wave-lengths are separated they have literally all the colors of the rainbow. The image produced by the separation of the white ray into all its colors is called a spectrum.

Now the basic idea of the spectroscope is to turn a ray of light from its path by refraction or diffraction. As it changes its path, the different wave-lengths turn at a different angle and in a reflection you see an image of all of them separately, that is of an infinite series of colors, instead of a plain spot of white sunlight.

Different kinds of light have different spectra. A burning body shows that it is burning by lines in its spectrum. It was first proved that the sun was a burning body by means of the spectroscope. The stars show a spectrum different from that of the sun, while the planets have a similar spectrum. Hence the planets must obtain their light from the sun while the stars are independent.

In a common spectroscope the strip formed on a screen by the beam of light, as of the sun, is received through a narrow slit and passed through a glass prism, being thus decomposed or separated into its constituent rays. This oblong strip consists of a number of colors, shading imperceptibly into one another, from red at one end, through orange, yellow, green, blue, indigo, to violet at the other. The strip seen is formed by an indefinite number of images of the slit, ranged in order and partially over-lapping.

The analysis or decomposition of the beam is due to the different refrangibilities of the component rays, the violet being the most refrangible and the red the least. Besides the visible color rays, the spectrum contains thermal or heating rays and chemical or actinic rays, which are not visible to the eye.

The heating effect of the solar spectrum increases in going from the violet to the red, and still continues to increase for a certain distance beyond the visible spectrum at the red end, while the chemical action is very faint in the red, strong in the blue and violet, and sensible to a considerable distance beyond the violet end. The actinic rays beyond the violet may be rendered visible by throwing them upon a surface treated with some fluorescent substance.

Besides this band of different colors, a pure solar spectrum will be found to possess a number of dark lines, which cut through it perpendicularly. These lines were first discovered by Wollaston, and were carefully studied by Frauenhofer and called after him Frauenhofer's lines. The lines are always to be found on the same spot and serve to indicate the exact places on the scale of color. For instance, if we use the term blue in the spectrum, this is naturally vague and incomplete, but by indicating the line on the spectrum in which this color is found no difficulty will arise. For this purpose Frauenhofer gave certain characteristic names to the line, which he indicated by letters. A certain line in the red he called A, another in the yellow D, and so on. As, however, these lines number some thousands a further subdivision of the letters was necessary to indicate them all.

In order to properly understand these lines it is necessary to remember five important things. These are: Firstly, an incandescent solid or liquid body gives out a continuous spectrum; secondly, an incandescent gaseous body gives out a discontinuous spectrum consisting of bright lines; thirdly, each element, when in the state of an incandescent gas, gives out lines peculiar to itself; fourthly, if the light of an incandescent solid or liquid passes through a gaseous body, certain of its rays are absorbed and black lines in the spectrum indicate the nature of the substance which absorbed the ray; fifthly, each element, when gaseous and incandescent, emits bright rays identical in color and position in the spectrum with those which it absorbs from light transmitted through it.

The spectrum of sodium, for instance, shows two bright lines which correspond in position with the double black line at D (the sodium line.) Now, applying these principles to the solar spectrum, investigators found, from the nature and position of the rays absorbed, that its light passes through hydrogen, potassium, sodium, calcium, barium, magnesium, zinc, iron, chromium, cobalt, nickel, copper and manganese, all in a state of gas and constituting part of the solar envelope, whence they conclude that these bodies are present in the substance of the sun itslf, from which they have been volatilized by heat.

The incandescent vapor of each elementary substance has a characteristic spectrum consisting of fixed lines, which never changes. Spectrum analysis, as this is called, furnishes the chemist with an exquisitely delicate test to enable him to detect the presence of minute quantities of elementary bodies. For instance, by heating any substance until it becomes gaseous and incandescent, he is able by means of the lines to read off from the spectrum the various elements present in the vapor. By this means several new elements have been discovered.

Photography has been of very great assistance to the spectroscopist by the means it has given him of not only making rapid and correct representation of the spectrum lines, but also in showing him a number of lines of very great importance situated in the ultra-violet parts of the spectrum, and which are totally invisible to the eye.

Professor Michelson has long been known as one of the most distinguished of American scientists. In 1907 he received the Nobel science prize, a sum of $40,000, for his researches into the nature of light. This is generally regarded as the highest international honor paid to scientists at the present time. It has been given to such men as Professor Roentgen, the discoverer of the Roentgen rays, and to Alexis Carrel, for his achievement in keeping animal tissues alive when separated from the body.

Few American scientists are more highly esteemed in Europe than Michelson. He has received a long list of honors from foreign scientific bodies, including the coveted Copley Medal of the Royal Society of London.

He was born in 1852, entered the United States Navy in 1873, and served as an officer. He became an instructor in physics at the Naval Academy in 1875. Since then he has held many university positions, and he has been head of the department of physics at the University of Chicago since 1892.

A very interesting personal fact about Professor Michelson is that in spite of his sixty-three years and his tremendous scientific labors he is a very fine athlete. Indeed, he believes that he would not have been able to do his scientific work so efficiently if he had not kept in constant physical training.

He is a particularly good tennis player and comparatively few of the younger men at the university can beat him at that game.

The Flying Auto of the French Army

QUITE the most remarkable feature dealing with the transportation of men, arms and supplies in the present war is the rapid movement of whole army corps, made possible by the use of automobiles and motor trucks. Formerly five to ten miles a day was considered the marching average of an army division Now, with the aid of these self-propelling vehicles, complete units of the French, British and German fighting forces are moved at nearly that rate per hour.

Military experts agree that if, with only the old transporting facilities, it would take three years to fight out the difference between the nations now at war, Lord Kitchener's estimate of one year is reasonable, largely on account of the extent to which motor vehicles are being used.

Ordinary rubber tires, however, refuse to grip snow-covered roads, as is the case also with roads a few inches deep with sand.

The sandy road problem has been solved by French manufacturers, who have supplied the French army in Morocco with "flying autos," and it is suggested that the same device may apply in the case of roads covered with snow. Instead of depending upon the grip of the driving wheels to send their motor cars over the sands of the Moroccan desert, French army officers have their vehicles equipped with air propellers, like those of aeroplanes and hydroplanes.

The propeller is mounted on a structure erected upon the rear of the chassis. Power is transmitted from the motor shaft to the propeller by a chain belt in such a way that the propeller can be used either independently or in conjunction with the driving wheels. Using the propeller alone these cars are said to be capable of a speed of fifty miles an hour over the desert, or over the sandiest roads. It is assumed that an ordinary fall of snow would be no more difficult for these "flying autos" to negotiate than so much sand.